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Variation of Heavy Metals Depth Wise along Horizontal Direction in Agricultural Soils

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Abstract

Industrialisation is a significant aspect in the growth of developing as well as developed countries. Growth of countries around the globe is not possible without industries. Past studies on groundwater, surface waters and soils reveal the presence of pollutants especially the heavy metals. These contaminants are translocated through the roots of plants to the other parts of plants also such as leaves, fruits and grains. Human as well as natural activities both contribute heavy metals into the soil. Number of studies on variation of heavy metals in soil depth wise are very less. Therefore the present study is carried out to analyse heavy metals in agricultural land at different depths and to find correlation between them. Heavy metals such as Zn, Pb, Cd, Cu, As, Fe, Cr III and Ni are analysed as per standards of APHA and IS. Mean concentration of organic carbon and the studied heavy metals (total Zn, Total Pb, Total Cu, Fe, Ni) is found to get decreased with depth. Mean concentration of Cd and Cr III increases with depth. With depth mean value of pH increases i.e. on the whole soil becomes more alkaline with depth.

Key words: Heavy metals, agricultural land, depth, mean concentration

Introduction

Industrialisation is a significant aspect in the growth of developing as well as developed countries. Growth of countries around the globe is not possible without industries. But the industrial process must be environment friendly considering the health of our mother earth as well as the living beings. The industrial waste whether in gaseous or liquid or solid form, must be disposed off after the required steps of treatment. But unfortunately the past studies on groundwater, surface waters and soils reveal the presence of pollutants especially the heavy metals. A study reveals the heavy metals in the groundwater, which is thought to be related to the soil's ability to absorb hazardous waste and untreated effluents from the nearby industrial activity into the aquifers. Thelevels of Pb,Cd, and Cr were higher than the permissible limits fixed by the WHO and NSDWQ [1],

These contaminants are translocated through the roots of plants to the other parts of plants also such as leaves, fruits and grains. Green leafy vegetables are found to possess various heavy metals as reported by numerous studies. In a study the concentration of Cd was found to be higher than the recommended values by WHO in sanitary wastewater, as well as Cd concentration in edible parts of spinachirrigated with sanitary waste water detected beyond the permissible limits [2].Indirectly we can say that heavy metals may enter into the food chain.

The soil has been threatened to the risk of heavy metals since long. Few of the metals most commonly present in the soil are- Cr, Ni, Cu, As, Cd, Pb and Hg. Among others are Ag, Co, Se, Mn, Ba and Al, which can also be found at high levels in the soil[3]. Environment and health are supposed to be at high risk. Source of heavy metals into

the soil can be both anthropogenic as well as lithogenic. The source lithogenic is referred to as the origin of heavy metals from the parent soil [3]. Other sources include weathering of rocks, volcanic eruptions, and natural events. Organic matter decay (biogenic source) can also release heavy metals into the soil [4]. Anthropogenic sources responsible towards contamination of soil by heavy metals include mining activities, agriculture and industrial effluents. Other sources include sewage waste water coming from mining area, alloys, paints and electronics that can release hazardous metals like As, Cd, Cr, Cu, Hg, Pb etc. soil gets contaminated after leaching of these materials into the soil that get accumulated with the passage of time [5]. Therefore human as well as natural activities both contribute heavy metals into the soil.

Number of studies on variation of heavy metals in soil depth wise are very less[6-7]. Therefore the present study is carried out to analyse heavy metals in agricultural land at different depths and to find correlation between them. A number of studies reveal contamination of the soil samples [8-15].

Materials and Methods

a) Study Area

The study are is an agricultural field that is present in village Salarpur in Tehsil Tijara present in District Alwar, Rajasthan. The village is surrounded by a number of industries including chemicals, textiles, metal smelting, automobiles etc. the groundwater and soil quality is communicated to be poor by the local residents. Therefore heavy metals are analysed in the agricultural field moving along horizontal direction and also along depth.

b) Sampling and analysis

Five samples of soil each about one kilogram were collected from an agricultural field with approximate area of 2500 square meters. Soil sampling locations were in a straight line along horizontal line of the field. Five samples were taken from points at about ten meters from each other in a straight line from 0 to 1 cm depth. Five samples of soil were taken from 1 to 5 cm depth from the same points along horizontal direction of the studied agricultural field. Soil samples were kept in clean and dry labelled plastic bags and transferred to laboratory.

Standard methods by IS and APHA were followed for testing and estimation of heavy metals in soil samples. Lumps were broken and samples were dried in air. pH of soil was measured by a calibrated pH meter. Heavy metals such as Zn, Pb, Cd, Cu, As, Fe, and Ni were estimated byinductively coupled plasma mass spectrometry (ICP-MS) after digestion with nitric acid and hydrogen peroxide.Cr III was estimated by spectrophotometric method.Organic carbon was determined by titrimetric method (Methods of Analysis of Soils, Plants, Waters, Fertilisers & Organic Manures-A Book by HLS Tandon).

Results and Discussion

a) Concentration of heavy metals

Table 1 presents the concentration of various heavy metals and pH in the samples of soil at 5 locations which are at ten meters from each other on moving along horizontal direction. Soil samples were taken from two different depths i.e. from 0-1 cm and 1-5 cm.

At 0-1 cm depth: pH varies from 7.86to 8.05with mean value 7.94. Organic carbon from 0.24 % to 0.36 % and mean value 0.312 %.

Total Zinc in the soil samples varies from 3.34mg/kg to 32.1mg/kg with mean value of 14.36mg/kg. Total lead from 0.29mg/kg to 7.91mg/kg with mean value of 2.898mg/kg. Total cadmium varies from 0 mg/kg to 0.27 mg/kg with mean value of 0.146mg/kg. Total Copper varies from 1.06mg/kg to 12.17mg/kg with mean value of 5.094mg/kg. Iron varies from 167.98mg/kg to 5838.15mg/kg with mean value of 2429.824mg/kg. Nickel varies from 0.96mg/kg to 140mg/kg with mean value of 33.77mg/kg. Chromium-III varies from 0 mg/kg to 0.56 mg/kg with mean value of 0.388mg/kg.

At 1-5 cmdepth: pH varies from 7.76 to 8.17 with mean value 8.034. Organic carbon varies from 0.25% to 0.38% with mean value 0.302%. Total Zinc in the soil samples varies from 4.7 mg/kg to 14.77 mg/kg with mean value of 9.328 mg/kg. Total lead from 0.33 mg/kg to 3.89 mg/kg with mean value of 1.366 mg/kg. Total cadmium varies from 0 mg/kg to 0.23 mg/kg with mean value of 0.166 mg/kg. Total Copper varies from 1.11 mg/kg to 5.9 mg/kg with mean value of 3.1 mg/kg. Iron varies from 175.24 mg/kg to 5822.56 mg/kg with mean value of 1351.908 mg/kg. Nickel varies from 1.36 mg/kg to 8.32 mg/kg with mean value of 3.702 mg/kg. Chromium-III varies from 0.38 mg/kg to 0.52 mg/kg with mean value of 0.432 mg/kg.

b) Comparative Study with depth *(Table 1)*

Table 1 reveals variation of pH, organic carbon and heavy metals with depth.

pH of all soil samples is alkaline. At location 1 and location 4, alkalinity of soil decreases slightly with depth but at location 2, 3 and 5 there is slight increase in alkalinity on increasing depth.

Organic carbon %, total Zn and total lead decreases with depth at locations 1, 2 and 4 but increases at location 3 and 5 with depth.

Total Cd concentration decreases with depth at locations 1, and 3, remains same at location 2 but increases at location 4 and 5 with depth. Total Cu decreases with depth at locations 1, 2 and location 4 but increases with depth at locations 3 and location 5. Fe concentration decreases with depth at all locations except at location 5 where it increases with depth. At location 1 and 2 decrease of Fe with depth is very large but after that decrease is quite lesser. Ni concentration also decreases with depth at location 1, 2 and 3. Ni concentration increases with depth at location 4 and 5. Maximum decrease in concentration of Ni with depth is at location 3. Chromium III concentration decreases with depth at locations 1, 4 and 5 but increases with depth at location 2 and 3. Interestingly at location 2 there is no Cr III at depth of 0 to 1 cm but still Cr III is found at 1 to 5 cm depth.

Mean concentration of organic carbon and the studied heavy metals (total Zn, Total Pb, Total Cu, Fe, Ni) decreases with depth. Mean concentration of Cd and Cr III increases with depth.

With depth mean value of pH increases i.e. on the whole soil becomes more alkaline with depth.

c) Correlation Study(Table2)

Correlation between parameters at 0 to 1 cm depth:

Strong positive correlation of Zn is revealed with - Pb, Cd with - Zn, Pb and Cu, Fe with - Ni.

Moderate positive correlation of organic carbon is observed - with Fe and Ni.

Weak positive correlation of pH is found with Cd and Cr III.

Perfect positive correlation of Cu is observed with - Zn and Pb.

Correlation between parameters at 1 to 5 cm depth:

Strong positive correlation of parameters at 1-5 cm depth is found as -

Organic carbon with pH, Zn, Pb, Cu, Fe and Ni. Zn with Pb, Cu and Ni. Pb with Cu, Fe, Ni, Fe with Ni and Cr. Cu with Ni.

Moderate correlation is observed as-

pH with Zn, Pb, Cu and Ni. Cr III with organic carbon, Pb, Cu and Ni. Zn with Fe. Cu with Fe.

Weak positive correlation is revealed between pH and Fe and between Zn and Cr III. Cd and Fe have strong negative correlation.

Correlation ofparameters at 1 to 5 cm depth with parameters at 1 to 5 cm depth:

Strong positive correlation is revealed between- Organic carbon (0-1cm) with- Zn, Cu and Ni (1-5cm). Fe (0-1 cm) with Pb, Fe, Ni and Cr III (1-5 cm). Ni (0-1cm) with Organic carbon, Pb, Ni and Cr III (1-5cm).

Moderate correlation is observed between- Organic carbon (0-1cm) with organic carbon, Pb, Fe, Cr III (1-5cm). Cd (1-5 cm) with Zn and Pb (0-1cm). Cu (0-1cm) with Cd (1-5cm). Fe (0-1cm) with organic carbon, Zn and Cu (1-5cm). Ni (0-1cm) with Zn and Cu (1-5cm).

Weak correlation is revealed between- Cd (0-1cm) with pH and Cd (1-5cm). Fe and Ni (0-1cm) with pH (1-5cm). Cr III (0-1cm) with Cr III (1-5 cm).

Perfect correlation is observed between Ni (0-1cm) and Fe (1-5cm).

Table1 Concentration of heavy metals in soil samples from 0-1 cm and 1-5 cm depth

Parameters	HS-depth (cm)	Location-1	Location-2	Location-3	Location-4	Location-5	Min.	Max.	Mean
pH	0 to 1	8.03	7.86	7.86	7.9	8.05	7.86	8.05	7.94
	1 to 5	7.96	8.13	8.15	7.76	8.17	7.76	8.17	8.034
Organic Carbon(OC)	0 to 1	0.31	0.35	0.36	0.3	0.24	0.24	0.36	0.312
	1 to 5	0.27	0.32	0.38	0.25	0.29	0.25	0.38	0.302
Total Zinc (as Zn)	0 to 1	32.1	26.54	3.34	5.94	3.88	3.34	32.1	14.36
	1 to 5	7.07	14.73	14.77	4.7	5.37	4.7	14.77	9.328
Total Lead (as Pb)	0 to 1	7.91	5.58	0.29	0.42	0.29	0.29	7.91	2.898
	1 to 5	0.55	1.65	3.89	0.33	0.41	0.33	3.89	1.366
Total Cadmium (as Cd)	0 to 1	0.27	0.21	0.1	0	0.15	0	0.27	0.146
	1 to 5	0.23	0.21	0	0.19	0.2	0	0.23	0.166
Total Copper (as Cu)	0 to 1	12.17	9.72	1.15	1.37	1.06	1.06	12.17	5.094
	1 to 5	1.77	5.25	5.9	1.11	1.47	1.11	5.9	3.1
Iron (Fe)	0 to 1	3529.34	2393.61	5838.15	220.04	167.98	167.98	5838.15	2429.824
	1 to 5	277.65	261.28	5822.56	175.24	222.81	175.24	5822.56	1351.908
Nickel (Ni)	0 to 1	14.48	12.12	140	1.29	0.96	0.96	140	33.77
	1 to 5	1.93	5.37	8.32	1.53	1.36	1.36	8.32	3.702
Chromium(Cr-III)	0 to 1	0.48	0	0.49	0.56	0.41	0	0.56	0.388
	1 to 5	0.44	0.39	0.52	0.43	0.38	0.38	0.52	0.432

Abbreviations: HS- Horizontal soil, Min. - Minimum, Max. - Maximum
Units: pH- unit less, concentrations of heavy metals- mg/kg, OC- %

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Table 2 Correlation matrix showing correlation of heavy metals in soil samples the depth of 0-1cm and 1-5 cm.

	pH(0-1)	OC(0-1)	Zn(0-1)	Pb(0-1)	Cd(0-1)	Cu(0-1)	Fe(0-1)	Ni(0-1)	Cr-III(0-1)	pH (1-5)	OC(1-5)	Zn(1-5)	Pb(1-5)	Cd(1-5)	Cu(1-5)	Fe(1-5)	Ni(1-5)	Cr-III(1-5)
pH(0-1)	1																	
OC(0-1)	-0.82	1																
Zn(0-1)	0.13	0.29	1															
Pb(0-1)	0.19	0.27	**0.99**	1														
Cd(0-1)	0.42	0.07	**0.82**	**0.85**	1													
Cu(0-1)	0.14	0.3	1	1	**0.84**	1												
Fe(0-1)	-0.37	0.77	0.18	0.23	0.29	0.22	1											
Ni(0-1)	-0.49	0.62	-0.35	-0.31	-0.16	-0.3	**0.85**	1										
Cr-III(0-1)	0.32	-0.32	-0.48	-0.41	-0.47	-0.5	0.02	0.21	1									
pH (1-5)	0.04	0.09	-0.06	-0.04	0.45	-0	0.36	0.39	-0.49	1								
OC(1-5)	-0.52	0.62	-0.23	-0.21	0.05	-0.2	0.77	**0.88**	-0.25	**0.73**	1							
Zn(1-5)	-0.71	**0.85**	0.17	0.15	0.23	0.19	0.73	0.65	-0.59	0.58	**0.87**	1						
Pb(1-5)	-0.64	0.75	-0.24	-0.22	-0.08	-0.2	**0.84**	**0.95**	-0.09	0.51	**0.96**	**0.85**	1					
Cd(1-5)	0.52	-0.51	0.57	0.53	0.39	0.53	-0.7	-1	-0.28	-0.3	-0.8	-0.56	-0.9	1				
Cu(1-5)	-0.72	**0.83**	0.04	0.03	0.14	0.07	**0.74**	0.72	-0.51	0.6	**0.91**	**0.99**	**0.9**	-0.65	1			
Fe(1-5)	-0.48	0.57	-0.43	-0.39	-0.23	-0.4	**0.81**	1	0.25	0.38	**0.86**	0.61	**0.94**	-0.99	0.69	1		
Ni(1-5)	-0.73	**0.83**	-0.11	-0.11	-0.01	-0.1	**0.81**	**0.87**	-0.28	0.52	**0.95**	**0.93**	**0.98**	-0.82	**0.97**	**0.85**	1	
Cr-III(1-5)	-0.42	0.6	-0.25	-0.2	-0.25	-0.2	**0.82**	**0.9**	0.5	-0	0.59	0.4	**0.76**	-0.85	0.46	**0.89**	0.66	1

= Strong positive correlation = Moderate positive correlation

= Low positive correlation = Perfect positive correlation

Conclusion

The study of soil samples along horizontal line of the agricultural field reveals that-

1. Mean concentration of organic carbon and the studied heavy metals (total Zn, Total Pb, Total Cu, Fe, Ni) decreases with depth. Mean concentration of Cd and Cr III increases with depth.

2. With depth mean value of pH increases i.e. on the whole soil becomes more alkaline with depth.

3. Fe and Ni have strong positive correlation, even Ni at 0-1cm depth is perfectly correlated with Fe at 1-5cm depth.

4. At both of the depths positive correlation is observed between Zn and Pb, between organic carbon and Cu, Fe and Cu with Zn, Pb.

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